SOLAR RADIATION INTENSITIES DURING JANUARY, FEBRUARY, AND MARCH, 1915; AND THE TOTAL SOLAR AND SKY RADIATION DURING MARCH, AT WASHINGTON, D. C.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated Washington, Apr. 28, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University, Washington, D. C., during January, February, and March, 1915.

A comparison of the monthly means with the 5-year normals published in the Bulletin of the Mount Weather Observatory, 5:182, Table 3, shows only slight departures from the normal in January and February. For the month of March, however, the means are considerably in excess of the normal.

At noon, on February 28, with the sun at zenith distance 47.7° and the corresponding air mass 1.48, the radiation intensity measured 1.50 calories per minute, which is as high as any measurement ever obtained in Washington.

Skylight polarization, measured at solar distance 90° and in the sun's vertical, with the sun at zenith distance 60°, averaged 63 per cent in January and 65 per cent in February and March, with maxima of 70 per cent in January, 69 per cent in February, and 71 per cent in March. Comparing these latter with the average monthly maxima and departures published in the Bulletin of the Mount Weather Observatory, 3:114, Table 16, it is seen that the maxima for January and February, 1915, are very close to the highest heretofore observed in these months and that the maximum for March exceeds the previous March maximum by 4 per cent.

TABLE 1.—*Solar radiation intensities at Washington, D. C., during January, February, and March, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance. 48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. A. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Jan. 1	.....	1.09	0.93	0.80	0.69	.....	.....	.....	.....	.....
3	.....	1.29	1.22	.....	.....	.....	.....	.....	0.73	.....
5	.....	.....	0.87	0.81	0.75	0.69	0.64	0.60	0.55	0.51
7	.....	1.36	1.28	1.20	1.12	1.04	0.98	0.93	0.89	.....
8	.....	1.28	1.19	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	0.93	.....	.....	.....	.....	.....	.....
13	.....	1.30	1.17	1.13	1.06	1.00	0.93	0.88	0.84	0.77
15	.....	1.17	1.04	0.92	0.85	0.75	0.67	0.64	0.57	0.52
26	.....	1.16	1.01	.....	.....	.....	.....	.....	.....	.....
29	.....	1.23	1.12	1.02	0.92	0.81	0.77	0.65	0.58	0.54
Means	.....	1.24	1.09	0.97	0.90	0.86	0.80	0.74	0.69	0.58
P. M.										
Jan. 5	.....	.....	1.11	1.02	0.93	0.86	0.82	0.79	0.76	0.70
7	.....	.....	1.21	1.08	0.99	0.94	0.89	0.82	0.74	0.71
8	.....	.....	1.21	1.10	1.01	0.94	0.88	0.82	0.77	0.72
10	.....	1.07	0.98	.....	.....	.....	.....	.....	.....	.....
13	.....	.....	1.18	1.13	.....	.....	.....	.....	.....	.....
15	.....	1.28	1.12	0.99	.....	.....	.....	.....	.....	.....
16	.....	1.05	0.87	.....	.....	.....	.....	.....	.....	.....
26	.....	1.16	.....	.....	.....	.....	.....	.....	.....	.....
29	.....	1.09	0.90	0.76	0.67	0.59	0.51	0.45	0.40	.....
Means	.....	1.13	1.07	1.01	0.90	0.83	0.78	0.72	0.67	0.71
A. M.										
Feb. 8	.....	1.04	0.94	0.84	.....	.....	.....	.....	.....	.....
9	1.31	1.21	1.03	0.94	0.84	0.76	0.68	0.61	.....	.....
10	1.47	1.37	1.27	1.18	1.13	.....	.....	.....	.....	.....
11	.....	0.91	.....	.....	.....	.....	.....	.....	.....	.....
18	1.47	1.40	1.28	1.20	1.15	1.05	0.96	0.93	.....	.....
19	.....	1.36	1.29	1.21	1.16	1.11	1.05	1.00	0.95	0.91
20	1.38	1.25	.....	.....	.....	.....	.....	.....	.....	.....
21	.....	1.17	.....	.....	.....	.....	.....	.....	.....	.....
26	1.42	1.31	1.15	1.01	0.93	0.88	0.84	0.80	.....	.....
27	.....	.....	.....	.....	0.89	0.78	0.72	0.66	.....	.....
Means	1.41	1.22	1.16	1.06	1.02	0.92	0.85	0.80	(0.95)	(0.91)

TABLE 1.—*Solar radiation intensities at Washington, D. C., during January, February, and March, 1915*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance. 48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. P. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Feb. 6	.....	.....	.....	.....	0.84	0.74	.....	.....	.....	.....
9	.....	1.29	1.20	1.12	1.04	0.97	0.90	0.83	0.78	0.74
10	.....	1.37	1.27	1.18	1.09	1.02	0.96	0.91	0.87	0.82
11	.....	1.03	0.85	0.68	.....	.....	.....	.....	.....	.....
18	.....	1.39	1.29	1.20	1.12	1.04	0.98	0.94	0.90	0.85
19	.....	1.31	1.19	1.10	1.00	0.95	0.88	0.82	.....	.....
20	.....	1.23	.....	.....	.....	.....	.....	.....	.....	.....
25	.....	.....	1.01	.....	.....	.....	.....	.....	.....	.....
26	1.42	1.30	1.19	1.10	1.02	0.92	0.79	.....	.....	.....
27	.....	.....	.....	.....	.....	0.77	0.68	.....	.....	.....
28	1.49	1.37	1.25	1.15	1.05	0.97	0.89	0.81	0.75	.....
Means	(1.46)	1.29	1.16	1.08	1.02	0.92	0.87	0.86	0.82	0.80
A. M.										
Mar. 2	.....	1.13	1.00	0.88	0.77	.....	.....	.....	.....	.....
3	1.39	1.33	1.24	1.12	1.01	.....	0.82	.....	.....	.....
4	1.44	1.34	1.25	1.18	1.11	1.05	1.00	0.94	0.90	.....
8	1.36	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	1.43	1.30	1.19	1.11	1.04	0.97	0.91	0.88	0.84	0.81
10	.....	1.23	1.08	0.93	0.76	0.67	0.62	0.58	0.55	0.51
12	1.43	1.30	1.20	1.14	1.07	0.99	0.92	0.86	0.82	0.78
13	1.45	1.37	1.27	1.17	1.13	1.08	1.01	0.96	0.91	0.87
19	.....	.....	0.80	.....	.....	.....	.....	.....	.....	.....
21	1.35	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	1.15	1.05	0.91	.....	.....	.....	.....	.....	.....	.....
25	.....	.....	.....	0.82	0.71	0.64	0.59	0.53	0.48	0.43
29	1.27	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	1.34	1.25	1.16	1.01	0.91	0.84	.....	.....	.....	.....
31	.....	1.09	0.99	0.89	0.82	0.76	0.70	0.64	0.57	.....
Means	1.36	1.24	1.10	1.02	0.93	0.88	0.82	0.77	0.72	0.68
P. M.										
Mar. 1	1.44	1.31	1.14	.....	.....	.....	.....	.....	.....	.....
3	1.42	1.29	1.21	1.11	1.03	0.97	0.91	0.85	0.79	0.74
4	1.45	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	1.40	1.27	1.16	1.03	0.88	0.79	0.71	0.58	0.49	.....
12	1.43	1.29	1.20	1.11	1.03	0.95	0.89	.....	.....	.....
13	1.41	1.31	.....	.....	.....	.....	.....	.....	.....	.....
15	1.08	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	1.15	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	.....	.....	.....	0.90	.....	.....	.....	.....	.....	.....
29	1.27	1.20	1.07	0.96	0.88	.....	.....	.....	.....	.....
31	1.30	1.23	1.06	0.94	0.84	0.75	0.69	0.65	0.61	0.55
Means	1.34	1.27	1.14	1.01	0.93	0.86	0.80	0.69	0.63	(0.64)

TABLE 2.—*Daily totals and departures of solar and sky radiation, at Washington, D. C., during March, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily total.	Departure from normal.	Excess or deficiency since first of month.	Possible sunshine.	Average cloudiness.
	Gr.-cal.	Gr.-cal.	Gr.-cal.	Per cent.	0—10
	415	107	107	84	5
	392	82	189	100	1
3	460	147	336	100	2
4	466	150	486	88	3
5	121	−197	289	4	10
6	133	−188	101	3	10
7	336	13	114	35	9
8	342	17	131	68	4
9	480	152	283	100	0
10	428	98	381	99	2
11	300	− 32	349	61	7
12	502	167	516	100	0
13	479	142	658	100	1
14	452	113	771	99	2
15	398	57	828	80	4
16	320	− 23	805	−63	9
17	470	125	930	98	5
18	423	76	1,006	92	7

TABLE 2.—*Daily totals and departures of solar and sky radiation, at Washington, D. C., during March, 1915*—Continued.

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily total.	Departure from normal.	Excess or deficiency since first of month.	Possible sunshine.	Average cloudiness.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0—10*
19	206	−144	862	48	8
20	261	− 91	771	60	9
Decade departure			390		
21	486	132	903	98	2
22	371	15	918	82	6
23	285	− 73	845	52	7
24	234	−126	719	39	8
25	442	80	799	79	5
26	251	−113	686	55	6
27	497	131	817	90	5
28	522	154	971	100	1
29	552	182	1,153	100	1
30	543	171	1,324	83	5
31	564	190	1,514	100	0
Decade departure			733		
Total excess or deficiency since first of year			−241		

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface. The measurements were made with a Callendar recording pyrheliometer as described in this REVIEW p. 100. Column 3 gives the departures from the daily normals given in this REVIEW, p. 106, Table 4.

The above data show less than the average cloudiness, more than average sunshine, and solar radiation above the average in intensity during March, 1915.

THERMO-ISOPLETHS FOR WASHINGTON, D. C.

By CLEVELAND ABBE, Jr.

[Dated: Washington, D. C., May 1, 1915.]

On another page Prof. H. H. Kimball presents a diagram of isopleths of the combined solar and sky radiation received at Washington, D. C., throughout the year. It is of much interest to compare with such a fundamental element the resultant surface air temperatures at the same locality; and by using a similar graphic method the comparison of cause and effect is facilitated. It is important to bear in mind that the scale of hours is not the same in the two diagrams. Insolation is a function of the sun's altitude and is always referred to solar altitudes in the primary work. Hence apparent time is used in diagrams of radiation isopleths while 75th meridian time serves for the thermo-isopleths presented herewith. The

TABLE 1.—*Average hourly temperatures* (°F.) *by months at Washington, D. C., for the period 1890–1910.*

[Seventy-fifth meridian time.]

Month.	A. M.												P. M.												Mean.
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mid-night.	
January	31.8	31.3	30.8	30.5	30.2	29.9	29.6	29.9	31.0	32.9	34.8	36.4	37.6	38.8	39.3	39.3	38.5	37.3	36.0	35.0	34.1	33.5	32.8	32.3	33.9
February	31.4	30.8	30.4	30.1	29.6	29.4	29.2	29.8	31.1	33.0	35.1	36.9	38.2	39.3	40.0	40.1	39.3	38.1	36.6	35.6	34.5	33.7	33.0	32.4	34.1
March	40.3	39.7	39.1	38.4	37.9	37.6	37.4	38.9	40.9	42.9	45.0	46.8	48.4	49.6	50.2	50.3	49.8	48.7	46.9	45.5	44.0	42.9	42.0	41.2	43.5
April	48.9	48.0	47.2	46.5	45.8	45.4	46.6	49.3	51.7	54.1	56.2	58.0	59.5	60.7	61.2	61.5	61.0	59.8	58.0	56.2	54.2	52.7	51.5	50.4	53.5
May	58.5	57.7	56.9	56.2	55.5	55.8	57.7	60.5	62.9	65.1	67.3	68.9	70.2	71.3	71.7	71.7	71.1	70.0	67.8	65.5	63.3	61.9	60.6	59.6	63.6
June	66.3	65.6	64.8	64.2	63.6	64.3	66.4	69.2	71.5	73.7	75.6	77.1	78.3	79.2	79.5	79.4	78.7	77.6	75.6	73.3	71.1	69.7	68.4	67.5	71.7
July	70.7	70.1	69.4	68.8	68.1	68.4	70.5	73.3	75.9	78.1	80.1	81.6	82.8	83.5	83.6	83.4	82.3	81.1	79.0	76.7	74.7	73.5	72.4	71.5	75.8
August	69.3	68.8	68.1	67.6	66.9	66.8	68.4	71.2	73.8	76.1	78.1	79.6	80.8	81.7	81.9	81.6	80.9	79.6	77.0	74.9	73.0	71.3	70.8	70.0	74.1
September	63.4	62.8	62.2	61.6	61.1	60.7	61.5	64.6	67.7	70.4	72.8	74.5	75.8	76.7	77.1	76.8	75.8	73.8	70.8	68.6	66.8	65.6	64.7	63.8	68.3
October	51.4	50.8	50.2	49.8	49.4	49.0	49.2	51.6	54.6	57.5	60.0	61.9	63.4	64.4	64.8	64.5	63.2	60.6	57.8	56.1	54.6	53.6	52.6	51.8	56.0
November	42.0	41.5	41.0	40.5	40.2	39.9	39.7	40.8	43.1	45.8	48.2	50.0	51.5	52.4	52.8	52.2	50.8	49.0	47.3	46.0	44.6	43.8	43.0	42.3	45.4
December	33.1	32.7	32.3	31.9	31.5	31.2	31.1	31.6	33.0	35.1	37.2	39.0	40.3	41.4	41.8	41.5	40.4	38.9	37.5	36.5	35.4	34.7	34.0	33.5	35.7

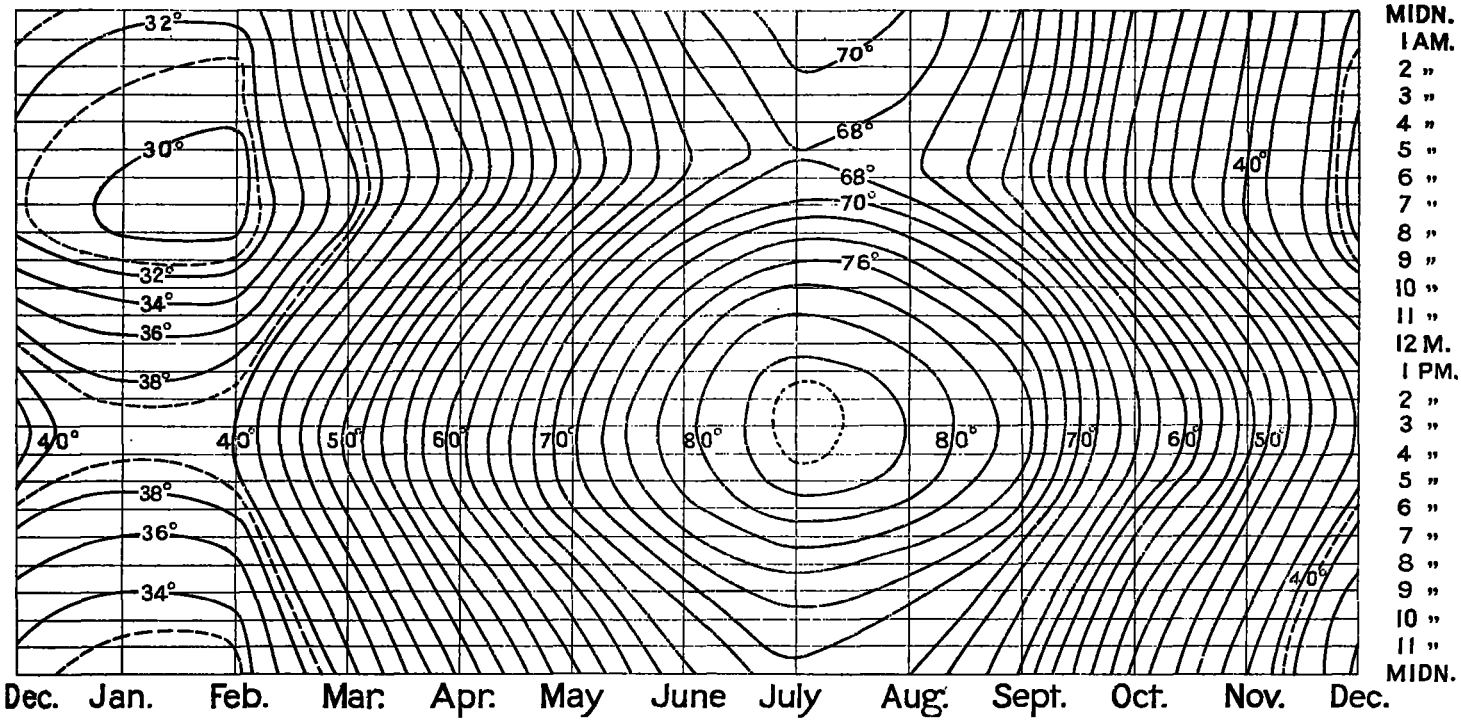

FIG. 1.—Thermo-isopleths for Washington, D. C., for the period 1890–1910. (°F.; 75th meridian time.)